1 SRI-CAT BEAMLINES, TECHNICAL DEVELOPMENTS, AND SCIENTIFIC APPLICATIONS

1.1 Introduction

In May 2002, the Advanced Photon Source (APS) was reorganized into three divisions: the Accelerator Systems Division (ASD), the APS Operations Division (AOD), and the Experimental Facilities Division (XFD). Parts of the former User Program Division (UPD) were incorporated into XFD; other parts were incorporated into AOD. This *Progress Report* summarizes the main scientific and technical activities of XFD and parts of the former UPD from January 2001 through June 2002.

The report is divided into two major sections, 1) SRI-CAT Beamlines, Technical Developments, and Scientific Applications, and 2) User Technical Support, which describe the technical activities and research and development (R&D) accomplishments of the XFD and former UPD personnel in supporting the synchrotron radiation instrumentation (SRI) collaborative access team (CAT) and the general APS user community. Also included in this report is a comprehensive list of publications (see Appendix) by XFD and UPD staff members during the time period covered by this report.

The SRI CAT members have made a major impact on the development of new synchrotron radiation optics, instrumentation, and techniques. These state-of-the-art developments have attracted significant scientific community to SRI CAT beamlines and experimental capabilities. In the last two years, SRI CAT conducted collaborative research with more than 100 groups from different institutions and universities. In fall 2002, SRI CAT scheduled more than 50% of beam time for general users proposals. Both of these facts are clear illustration of the dedication of the SRI CAT staff to serve the user community effectively.

In addition to general user support on instrumentation development, SRI CAT has served the synchrotron radiation community in other ways as well. The SRI CAT often served as a test-bed for new accelerator concepts, such as quantitative characterization of the microfocused flux and beam coherence with reduced emittance operation in sector 2 and the canted undulator scheme for operating two beamlines from a single straight section, a prototype of which has been implemented in sector 4. The SRI CAT played an important part in better understanding the effect of top-up on photon beam stability and how these effects can be mitigated through gating techniques.

Members of SRI CAT have also played important roles in the development and running of the National School for Neutron and X-ray Scattering, which has been hosted by Argonne National Laboratory (ANL) for the last several summers. The goal of the school is to provide training for graduate students in the use of national user facilities, such as the APS.

SRI CAT also organized several user science workshops on biological/biomedical applications of x-ray microscopy, polarized x-rays, inelastic x-ray scattering, and nanoscale materials research. New initiatives drawing upon these workshops have resulted in new CATs, such as IXS CAT and Nano-CAT.

Significant accomplishments also took place in the area of user technical support. Staff members from both XFD and ASD completed the final design of the straight section and front end that accommodates the canted undulator setup—the system of choice for new structural biology CATs.

Advanced crystal, zone plate, and mirror x-ray optics have been developed with strong collaboration with the APS user community. Especially noteworthy is the development of profile coating by sputter deposition for the production of aspherical x-ray optical surfaces. This technology has recently been applied to fabricate elliptically shaped Kirkpatrick-Baez mirrors. Also noteworthy is the development and fabrication of a refractory x-ray lens having an adjustable focus.

Significant progress has been made in the area of high-energy x-ray technique development. In particular, the development of high-energy small-angle scattering combined with high-energy wide-angle scattering is proving to be a powerful new technique to study materials systems. The combination of these two techniques allows the gathering of information on texture, strain, and phase with simultaneous information on longer length scales probed by small-angle scattering.

Noteworthy advances were made in both x-ray microscopy techniques and applications, especially in the biological and materials sciences. Highlights in this report include trace element analysis in marine protists by scanning fluorescence microscopy and microdiffraction imaging of antiferro-magnetic domains in chromium.

The program that utilizes polarization properties of x-rays advanced significantly in the last year. As an example, the strength and extent of interlayer exchange coupling and magnetic roughness was measured on Gd/Fe multilayers. This quantitative information was obtained by performing both x-ray resonance exchange scattering (XRES) and x-ray magnetic circular dichroism (XMCD) measurements.

Both SRI-CAT and user technical support have reached a mature state and are prepared for new challenges in the future.

1.2 X-ray Imaging and Optics Development

The effort in x-ray optics and imaging is on development of x-ray interferometers, development of propagation phase-contrast imaging, and high-heat-load optics. In particular, the phase-contrast imaging experiments are being conducted with scientists who were previously not synchrotron users. Through these collaborations, we hope to open a new experimental field to researchers in areas such as entomology.

1.2.1 Fresnel Propagation X-ray Phase-Contrast Imaging

The contrast in this technique is due to Fresnel diffraction. It corresponds to the defocusing technique in electron microscopy and is sensitive to the second derivative of